

Attorney Docket No. NORT-019

## APPLICATION

**FOR UNITED STATES LETTERS PATENT**

## SPECIFICATION

18 TO ALL WHOM IT MAY CONCERN:

19  
20 BE IT KNOWN THAT I, **Mel D. Falcon**, a citizen of the United States, have  
21 invented a new and useful coal bed methane wastewater treatment system of which the  
22 following is a specification:

1

2

3                   **Coal Bed Methane Wastewater Treatment System**

4

5

6                   **CROSS REFERENCE TO RELATED APPLICATIONS**

7       Not applicable to this application.

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10                  **STATEMENT REGARDING FEDERALLY  
11                  SPONSORED RESEARCH OR DEVELOPMENT**

12       Not applicable to this application.

13

14

15                  **BACKGROUND OF THE INVENTION**

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19       **Field of the Invention**

20

21       The present invention relates generally to desalination and more specifically it  
22       relates to a coal bed methane wastewater treatment system for efficiently and cost  
23       effectively treating wastewater generated from coal bed methane production.

24

25

26       **Description of the Related Art**

27

28       Coal bed methane ( $\text{CH}_4$ ) production has increased greatly since 1987. Methane  
29       is a flammable gas (the major constituent of natural gas) trapped in coal fractures by

1 water. When a well is drilled into the coal formation and the water is extracted, the  
2 trapped methane gas can also be recovered. Existing coal bed methane wells are  
3 producing millions of cubic feet of coal bed methane (CBM), but are also producing  
4 millions of gallons of CBM wastewater.

5

6 While CBM wastewater (CBMW) is suitable for domestic and stock use, it is  
7 generally toxic to plants and crops. CBMW can come from as deep as 700 feet below the  
8 surface, and generally contains high concentrations of dissolved salts (e.g. sodium,  
9 bicarbonate), making it unsuitable for irrigation. The ratio of dissolved salts (referred to as  
10 the sodium absorption ration, or SAR) of CBMW is many times the level native plants and  
11 most crops can tolerate. Soil irrigated with CBMW will accumulate these salts, which  
12 destroys soil structure and inhibits water absorption by plants.

13

14 Surface discharge to natural waterways is the easiest and most economical  
15 method of disposing of the CBMW. However, since CBMW has high levels of sodium  
16 and bicarbonates, severe environmental concerns have been raised (e.g. wildlife,  
17 plants, environment, etc.). Hence, discharging untreated CBMW directly into a natural  
18 waterway is not a feasible option.

19

20 Another method of treating CBMW is the usage of large wastewater  
21 impoundments (a.k.a. “holding ponds”, “infiltration ponds”, “zero discharge ponds”)  
22 within the ground surface that receive large volumes of CBMW. The CBMW within  
23 the impoundments eventually evaporates and filters into a shallow aquifer within the  
24 ground. The main problem with wastewater impoundments is that large acreages of  
25 land are required for this process. Another problem with wastewater impoundments is  
26 that the impoundments become contaminated with large amounts of sodium. Another  
27 problem with wastewater impoundments is that valuable quantities of water are lost to  
28 evaporation and shallow aquifers that are easily contaminated.

29

1       Another method of treating CBMW is to inject the CBMW back into an aquifer.  
2 While this approach avoids surface discharge, there is the potential for contamination of  
3 valuable aquifers and other environmental concerns.

4

5       Another method of treating CBMW is through conventional reverse osmosis or  
6 salt precipitation with an evaporation process that leaves the salt behind and traps the  
7 evaporated water. Conventional reverse osmosis is expensive and cost prohibitive with  
8 respect to CBMW. Evaporation and salt precipitation treatment is also not economical nor  
9 feasible with the large quantities of saline CBMW. Hence, there is a need for a CBMW  
10 treatment system that is efficient and cost effective.

11

12       While these devices may be suitable for the particular purpose to which they  
13 address, they are not as suitable for efficiently treating wastewater generated from coal  
14 bed methane production. Conventional CBMW treatments are inefficient and are  
15 costly to operate.

16

17       In these respects, the coal bed methane wastewater treatment system according  
18 to the present invention substantially departs from the conventional concepts and  
19 designs of the prior art, and in so doing provides an apparatus primarily developed for  
20 the purpose of efficiently treating wastewater generated from coal bed methane  
21 production.

22

23

1

2                   **BRIEF SUMMARY OF THE INVENTION**

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4         In view of the foregoing disadvantages inherent in the known types of  
5         wastewater treatment systems now present in the prior art, the present invention  
6         provides a new coal bed methane wastewater treatment system construction wherein  
7         the same can be utilized for efficiently and cost effectively treating wastewater  
8         generated from coal bed methane production.

9

10         The general purpose of the present invention, which will be described  
11         subsequently in greater detail, is to provide a new coal bed methane wastewater  
12         treatment system that has many of the advantages of the wastewater treatment systems  
13         mentioned heretofore and many novel features that result in a new coal bed methane  
14         wastewater treatment system which is not anticipated, rendered obvious, suggested, or  
15         even implied by any of the prior art wastewater treatment systems, either alone or in  
16         any combination thereof.

17

18         To attain this, the present invention generally comprises collecting wastewater  
19         into an ozone diffusion tank where ozone is injected into the wastewater, passing the  
20         wastewater through a prefilter tank and then through a primary membrane. The treated  
21         water is separated to a permeate tank and the concentrated water is passed through a  
22         secondary membrane for further separation. The concentrated water is then placed  
23         within a holding pond for evaporation thereof. The treated water may be utilized to  
24         clean the prefilter tank and the membranes. The treated water is then dispensed into a  
25         sodium adsorption ratio tank prior to being released to a natural waterway.

26

27         There has thus been outlined, rather broadly, the more important features of the  
28         invention in order that the detailed description thereof may be better understood, and  
29         in order that the present contribution to the art may be better appreciated. There are

1 additional features of the invention that will be described hereinafter and that will form  
2 the subject matter of the claims appended hereto.

3

4 In this respect, before explaining at least one embodiment of the invention in  
5 detail, it is to be understood that the invention is not limited in its application to the  
6 details of construction and to the arrangements of the components set forth in the  
7 following description or illustrated in the drawings. The invention is capable of other  
8 embodiments and of being practiced and carried out in various ways. Also, it is to be  
9 understood that the phraseology and terminology employed herein are for the purpose  
10 of the description and should not be regarded as limiting.

11

12 A primary object of the present invention is to provide a coal bed methane  
13 wastewater treatment system that will overcome the shortcomings of the prior art  
14 devices.

15

16 A second object is to provide a coal bed methane wastewater treatment system  
17 for efficiently and cost effectively treating wastewater generated from coal bed  
18 methane production.

19

20 Another object is to provide a coal bed methane wastewater treatment system  
21 that conserves valuable water resources during the exploitation of coal bed methane.

22

23 An additional object is to provide a coal bed methane wastewater treatment system  
24 that removes salts and other debris from coal bed methane wastewater.

25

26 A further object is to provide a coal bed methane wastewater treatment system  
27 that is capable of treating large volumes of wastewater.

28

1       Another object is to provide a coal bed methane wastewater treatment system  
2   that is in compliance with state and federal discharge standards.

3

4       A further object is to provide a coal bed methane wastewater treatment system  
5   that prevents pollution of natural waterways, crops, native plants and water supplies.

6

7       Another object is to provide a coal bed methane wastewater treatment system  
8   that provides water suitable for irrigation, stock water, recreation and potable usage.

9

10      Other objects and advantages of the present invention will become obvious to the  
11   reader and it is intended that these objects and advantages are within the scope of the  
12   present invention.

13

14      To the accomplishment of the above and related objects, this invention may be  
15   embodied in the form illustrated in the accompanying drawings, attention being called  
16   to the fact, however, that the drawings are illustrative only, and that changes may be  
17   made in the specific construction illustrated and described within the scope of the  
18   appended claims.

1

2                   **BRIEF DESCRIPTION OF THE DRAWINGS**

3

4         Various other objects, features and attendant advantages of the present  
5 invention will become fully appreciated as the same becomes better understood when  
6 considered in conjunction with the accompanying drawings, in which like reference  
7 characters designate the same or similar parts throughout the several views, and  
8 wherein:

9

10         FIG. 1 is a block diagram of the present invention.

11

12         FIG. 2 is a schematic illustration of the present invention.

13

14         FIG. 3 is a detailed schematic illustration of the present invention.

1

## 2 DETAILED DESCRIPTION OF THE INVENTION

3

### 4 A. Overview

5       Turning now descriptively to the drawings, in which similar reference  
6 characters denote similar elements throughout the several views, FIGS. 1 through 3  
7 illustrate a coal bed methane wastewater treatment system 10, which comprises  
8 collecting wastewater into an ozone diffusion tank 20 where ozone is injected into the  
9 wastewater, passing the wastewater through a prefilter tank and then through a primary  
10 membrane 40. The treated water is separated to a permeate tank 80 and the  
11 concentrated water is passed through a secondary membrane 50 for further separation.  
12 The concentrated water is then placed within a holding pond 60 for evaporation  
13 thereof. The treated water may be utilized to clean the prefilter tank and the  
14 membranes. The treated water is then dispensed into a sodium adsorption ratio tank  
15 prior to being released to a natural waterway 14.

16

### 17 B. Coal Bed Methane Wastewater (CBMW)

18       Coal bed methane wastewater (CBMW) is produced through a coal bed  
19 methane well 12 while coal bed methane (CBM) is simultaneously produced. CBM  
20 wells 12 are typically arranged close together, so the CBMW is typically combined  
21 into a combined pipeline. Figure 1 illustrates combining the CBMW from a plurality  
22 of CBM wells 12 prior to treating the same with the present invention. It can be  
23 appreciated that the present invention may be utilized with one or more CBM wells 12.

24

### 25 C. Ozone Diffusion Tank

26       As shown in Figures 1 through 3 of the drawings, the combined CBMW is input  
27 into an ozone diffusion tank 20. As shown in Figures 1 through 3 of the drawings, a  
28 plurality of ozone diffusion tanks 20 may be utilized that provide additional storage  
29 and wastewater detention time for the process of coagulation to be completed.

1  
2       Ozone is injected into the CBMW before entering the ozone diffusion tank **20**  
3 and/or within the ozone diffusion tank **20**. The injected ozone oxidizes iron,  
4 manganese and other metals within the CBMW. The injection of ozone into the ozone  
5 diffusion tank **20** also assists to flocculate, coagulate and agglomerate organic  
6 compounds and natural clays.

7  
8       The ozone diffusion tank **20** preferably has a cone bottom for collecting solids  
9 from the CBMW. The ozone diffusion tank **20** preferably has a purging functionality  
10 that allows for the ozone diffusion tank **20** to be automatically or manually purged to a  
11 holding tank for disposal of. The ozone diffusion tank **20** is preferably designed to  
12 maximize the interfacing of the ozone molecule with the water molecule.

13  
14 **D. Prefilter Tanks**

15       The CBMW from within the ozone diffusion tank **20** is then transported to one  
16 or more prefilter tanks **30**. The prefilter tanks **30** are designed to maximize the  
17 removal of suspended solids within the CBMW. The prefilter tanks **30** are preferably  
18 alternated to allow for continuous filtration of the CBMW while a backwashing cycle  
19 is performed on a previously utilized prefilter tank.

20  
21       The prefilter tanks **30** preferably have one or more perforated screens for  
22 removing larger particles within the CBMW. The screens are surrounded and filled to  
23 a desired level (e.g. 4 inches) above each of the screens with one or more gradations of  
24 ruby garnet.

25  
26       A filtration media is positioned within the prefilter tanks **30**. A exemplary  
27 filtration media is comprised of ceramic beads of uniform size and shape. The depth  
28 of the filtration media ranges preferably between 24 to 30 inches while allowing  
29 approximately fifty-percent free board to prevent the expelling of filtration media

1 during backwashing. Flow rates and pressures are calculated so as to maximize the  
2 filtering quality and quantity of the filtration media.

3

4 ***E. Primary Membrane***

5 The CBMW flows from the prefilter tanks **30** into the primary membrane **40** as  
6 shown in Figures 1 through 3 of the drawings. The CBMW primary membrane **40**  
7 separates the dissolved solids from the water molecules. The primary membrane **40**  
8 preferably desalinates 90% of the feed water.

9

10 The permeate (desalinated) water flows to a permeate tank **80** as further shown  
11 in Figures 1 through 3 of the drawings. The reject water with the dissolved solids  
12 flows to a secondary membrane **50** for further concentration of the reject water.

13

14 ***F. Secondary Membrane***

15 The secondary membrane **50** receives the reject water from the primary  
16 membrane **40** as shown in Figures 1 through 3 of the drawings. The secondary  
17 membrane **50** is preferably a high-pressure membrane for desalinating the CBMW.  
18 The primary membrane **40** preferably desalinates 50% of the feed water.

19

20 The permeate (desalinated) water flows to a permeate tank **80** as further shown  
21 in Figures 1 through 3 of the drawings. The reject water with the dissolved solids  
22 flows to a holding pond **60** for evaporation.

23

24 ***G. Permeate Tank***

25 The permeate tank **80** is comprised of one or more tanks that retains the  
26 permeate water from the primary membrane **40** and the secondary membrane **50**. The  
27 permeate water within the permeate tank **80** may be utilized to backwash the prefilter  
28 tank and for flushing the membranes **40, 50**. The flush and backwash water is then

1 distributed to the holding pond **60** as shown in Figure 1 of the drawings. The permeate  
2 water not utilized for flushing and backwashing is then transferred to the SAR tank **70**.  
3

4 **H. Sodium Absorption Ratio (SAR) Tank**

5 Permeate water from the permeate tank **80** is then transferred to the SAR tank  
6 **70** containing two compartments. The first compartment with the SAR tank **70** is  
7 designed with two perforated distributor modules. Gravel and garnet is placed around  
8 and above the distributors to protect the distributors while allowing up-flow of  
9 permeate water through a calcium carbonate bed. The calcium carbonate is preferably  
10 comprised of crushed limestone that dissolves relatively slowly and is easily  
11 replenished.

12

13 The de-mineralized permeate water dissolves and absorbs the calcium in the  
14 calcium carbonate which produces the offsetting calcium required to balance any  
15 sodium ion that remains in the permeate water. The first compartment is designed to  
16 allow for sufficient detention time for dissolving the calcium but not the calcium  
17 carbonate.

18

19 The second compartment within the SAR tank **70** is a holding tank with float  
20 level controls that allow the treated water to be pumped to a discharge point or natural  
21 waterway **14** as shown in Figures 1 through 3 of the drawings. The treated water may  
22 also be utilized for other purposes such as but not limited to irrigation, drinking or  
23 returned to an aquifer.

24

25 **I. Holding Pond**

26 The holding pond **60** may be comprised of any structure or ground formation  
27 capable of receiving/storing a large volume of reject water. Reject water from the  
28 secondary membrane **50** along with the flush/backwash water is transferred to the  
29 holding pond **60** for evaporation utilizing conventional evaporation technology. The

1 holding pond **60** is preferably positioned in a location that maximizes exposure to  
2 prevailing winds.

3

4 An evaporation system **64** is preferably utilized within the holding pond **60**  
5 which enhances the evaporation of the water within the holding pond **60**. The holding  
6 pond **60** is preferably designed to have a permeable divider **62** for separating a settling  
7 side and an evaporation side as shown in Figure 2 of the drawings. The evaporation  
8 system **64** is positioned within the evaporation side for inputting air into the water to  
9 enhance evaporation thereof.

10

11 The evaporation system **64** may utilize nozzles that spray the water within the  
12 holding pond **60** in a cone or umbrella shaped plume of water. Atomization of the  
13 water plume is enhanced by injecting air into a venturi below the nozzles. The venture  
14 effect also increases the temperature of the water thereby enhancing the evaporation  
15 process.

16

17 Another suitable evaporation process is comprised of a heat distillation process  
18 which will eliminate a large holding pond **60**. Various other technologies may be  
19 utilized to comprise the evaporation process.

20

21 As to a further discussion of the manner of usage and operation of the present  
22 invention, the same should be apparent from the above description. Accordingly, no  
23 further discussion relating to the manner of usage and operation will be provided.

24

25 With respect to the above description then, it is to be realized that the optimum  
26 dimensional relationships for the parts of the invention, to include variations in size,  
27 materials, shape, form, function and manner of operation, assembly and use, are  
28 deemed to be within the expertise of those skilled in the art, and all equivalent

1 structural variations and relationships to those illustrated in the drawings and  
2 described in the specification are intended to be encompassed by the present invention.

3

4 Therefore, the foregoing is considered as illustrative only of the principles of  
5 the invention. Further, since numerous modifications and changes will readily occur to  
6 those skilled in the art, it is not desired to limit the invention to the exact construction  
7 and operation shown and described, and accordingly, all suitable modifications and  
8 equivalents may be resorted to, falling within the scope of the invention.